The Accomplishments of the United States Railroad Administration in Unifying and Standardizing the Statistics of Operation

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THE standardization of statistics of operation, which has been brought about by the centralized control of the United States Railroad Administration, was intended primarily to aid the Director General and his staff, the Regional Directors, and the Federal Managers of the individual railroads, in keeping closer check on the efficiency of operation, as measured by units of transportation, equipment utilization and operating costs. Railroad officers, as a whole, now know more than they knew before about the details of the operation of their own properties, and they now know very much more than they knew before about their relative performance in comparison with neighboring roads. The publication of the monthly summaries by roads and by regions makes possible easy comparison of the results on one road with those of other roads operating under similar conditions, and enables each Regional Director to measure the efficiency of his region with that of neighboring regions without uncertainty or qualification as to bases and methods.

The value of the information made available by the new plan is not confined to railroad managers. The published summaries have opened up to the public regulating authorities, economists, investors and other students of transportation, a wealth of data which heretofore have not been available in comprehensive form or on uniform bases. This phase of the subject is of interest to the readers of The Annals, and it will be largely from this viewpoint that the following description of the plan, and the discussion of its underlying principles, will be undertaken.

STATISTICAL REQUIREMENTS OF THE INTERSTATE COMMERCE COMMISSION

At this point it is important to draw attention to the fact that the Interstate Commerce Commission in its classifications of

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revenues and expenses has made very little provision for statistics of operation. The emphasis throughout all of the classifications, and in the data required in the annual report, has been placed upon the features of finance and public service. By combinations of the statistics of transportation production, (ton-miles and passenger-miles) with statistics of train-, locomotive-, and car-mileage, it is possible to derive a few statistical units, such as the average net freight train-load, the passengers per train-mile, the tons per loaded freight car-mile, and the passengers per passenger car-mile. It is possible also to derive a few unit costs for the transportation service *as a whole*, but, generally speaking, the annual report form of the Commission does not provide sufficient data for the purposes of the analyst of operating efficiency.

This comment is not intended as a criticism. The standardization of railroad accounting is one of the noteworthy achievements of the Interstate Commerce Commission. It meets the requirements of the original Act to Regulate Commerce, and of its amendments. Section 20 of that Act, as amended, instructs the Commission to provide for "a uniform system of accounts and the manner in which such accounts shall be kept" and especially refers to

> capital stock issued, the amounts paid therefor, and the manner of payment for the same; the dividends paid, the surplus fund, if any, and the number of stockholders; the funded and floating debts and the interest paid thereon; the cost and value of the carrier's property, franchises, and equipments; the number of employees and the salaries paid each class; the accidents to passengers, employees, and other persons, and the causes thereof; the amounts expended for improvements each year, how expended, and the character of such improvements; the earnings and receipts from each branch of business; the balances of profit and loss; and a complete exhibit of the financial operations of the carrier each year, including an annual balance sheet. Such reports shall also contain such information in relation to rates or regulations concerning fares or freights, or agreements, arrangements, or contracts affecting the same as the Commission may require . . .

The absence of any reference to statistics which reflect the degree of operating efficiency is apparent. The viewpoint is that of protection of those who pay the freight, those who travel, and those who invest their money in railroad securities. The uniform system of accounts, therefore, does not include within its scope any standards of cost accounting nor any indices (in detail) of

managerial efficiency, except those which are reflected by the totals of the income account, the balance sheet, and the profit and loss account.

In the absence of required standards, the railroads continued and developed their own statistical systems individually, and there grew to be wide divergencies in practice, ranging from an almost entire absence of statistics other than those required by the Commission, to elaborate cost accounting and efficiency data. There was no uniformity, either as to the general scope of operating statistics or as to the methods or bases. Each railroad evolved its own statistical standards according to its own conception of what was necessary or desirable, and in each case the system, to a large extent, was a reflex of the interest taken personally in the figures by those in managerial authority. It was, therefore, extremely difficult for one road to compare its operating statistics with those of its neighbors, as there was seldom any assurance that the units bearing the same title really meant the same thing. For example, in the important feature of freight car utilization, Road A would compute its "Average miles per car-day" by including every freight car on its lines; Road B would exclude cars stored; Road C would exclude cars held under repairs or awaiting repairs as well as those stored. Some roads took count of the cars on the line once every month and used that as the divisor. Others took the average of two or four counts per month. Others took the daily average. In practically every unit of performance there were variations in practice which prevented comparisons without qualifications of some kind.

Under pre-war conditions, when each road or system was operated as an independent unit, this lack of standardization was not highly important. When, however, the roads were taken over by the government, and operation was begun as a single system under centralized management, this lack of statistical standardization was extremely embarrassing. For the purposes of intelligent control, centrally and by regions, a standardized plan was vital.

STANDARDIZATION BY UNITED STATES RAILROAD ADMINISTRATION

The Operating Statistics Section of the United States Railroad Administration was created on May 6, 1918, as a part of the Division of Operation, and instructed to "arrange for, and

supervise, the making of standardized reports and statistics pertaining to the maintenance and operation of railroads under Federal control, and to make such compilations of statistics as may be required."

The first work of the section was to design the standard forms. The aim was to continue the best in current practice, and at the same time to avoid placing too great a burden on the roads which had not been progressive in that respect. An effort was made to utilize all of the basic data required by the annual report forms of the Interstate Commerce Commission, and to superimpose upon that structure the additional information considered essential to a scientific exhibit of the more important phases of physical performance. The plan, as promulgated in August, 1918, did not completely embrace its intended scope, (as it was the intention to go into the details of maintenance of way and equipment, and into certain further details of transportation expenses) but the initial requirements are scientifically comprehensive without being carried so far toward the ideal as to be impracticable or unjustifiably burdensome.

LIST OF REGULAR MONTHLY REPORTS

Form 1, Freight Train Performance. This form calls for train-miles, locomotive-miles, car-miles, gross ton-miles, rating ton-miles, net ton-miles, train-hours, and the following averages and ratios (separately by directions):

Ratio of locomotive-miles to train-miles
Car-miles per train-mile (loaded, empty and total)
Gross ton-miles per train-mile
Rating (potential) ton-miles per train-mile
Net ton-miles per train-mile
Average speed in train-miles per train-hour
Gross ton-miles per train-hour
Net ton-miles per train-hour
Net ton-miles per loaded car-mile
Per cent loaded car-miles to total car-miles
Per cent net ton-miles to gross ton-miles
Per cent actual gross ton-miles to potential gross ton-miles

Form 2, Passenger, Mixed and Special Train Performance. This form calls for less detail than the report on freight train performance, as the passenger service does not lend itself so readily

to statistical control. Freight trains, with certain exceptions, are not run unless there are sufficient cars awaiting movement to make up full train-loads. The passenger service, on the other hand, is practically fixed by the public time-table, and the trains are run regardless of the fluctuations in the number of passengers. The superintendent has little control over the minimum passenger train service, although he can regulate the use of extra cars or extra trains. Form 2 provides for train-mileage, locomotive-mileage, and car-mileage, separated by classes of cars. The statistics are reported separately for passenger trains, mixed trains and special trains. The averages and ratios for passenger trains are:

Ratio of locomotive-miles to train-miles
Car-miles per train-mile
- Passenger cars
- Sleeping, parlor, and observation cars
- Dining cars
- Other passenger train cars
- Total

Form 3, Locomotive Performance. This report calls for statistics of performance and of fuel consumption of freight, passenger and yard switching locomotives. From the basic information are derived the following averages or ratios:

FREIGHT SERVICE

Gross ton-miles per locomotive-mile
Net ton-miles per locomotive-mile
Locomotive-miles per locomotive-day, serviceable locomotives
Locomotive-miles per locomotive-day, all locomotives
Net ton-miles per locomotive-day, all locomotives
Per cent of unserviceable locomotives
Pounds of coal per locomotive-mile
Pounds of coal per 1000 gross ton-miles

PASSENGER SERVICE

Car-miles per locomotive-mile
Locomotive-miles per locomotive-day, serviceable locomotives
Locomotive-miles per locomotive-day, all locomotives
Per cent of unserviceable locomotives
Pounds of coal per locomotive-mile
Pounds of coal per car-mile

YARD SWITCHING SERVICE

Locomotive-miles per locomotive-day, serviceable locomotives
Locomotive-miles per locomotive-day, all locomotives
Per cent of unserviceable locomotives
Pounds of coal per locomotive-mile

Form 4, Distribution of Locomotive Hours. This is an entirely new report which calls for the total number of locomotive-hours and their distribution by classes, (freight, passenger, yard switching and others) and a complete record of the hours spent on the road between terminals, the hours spent at terminals before beginning and after completing the road run, the hours spent in the enginehouse, and the hours spent in the shop or awaiting repairs. The aim is first to separate the serviceable from the unserviceable locomotives, and then, for each class of service, to show the division of serviceable locomotive time between hours devoted to the production of train-miles and hours of unproductive time.

Form 5, Freight Traffic Movement and Car Performance. This form provides an exhibit of the total volume of freight traffic and of freight car efficiency, and shows the average number of cars on the road daily (separated between serviceable and unserviceable), the net ton-miles, the train-miles, and the car-miles. It includes the statistics of mixed trains as well as those of freight trains. (Form 1 is confined exclusively to freight trains.) The averages follow:

Net ton-miles per mile of road per day
Net ton-miles per train-mile
Per cent of cars on line to cars owned
Per cent of cars in or awaiting shop to total on line
Net tons per loaded car-mile
Per cent of loaded car-miles to total car-miles
Car-miles per car-day
Net ton-miles per car-day

Forms 1 to 5, inclusive, relate entirely to what is termed physical performance. The dollar mark does not appear on any of the five forms. Consequently they are independent of the expenditure accounts. The distinction is important from the viewpoint of early availability. The accounts relating to expenditures ordinarily are not closed until the 20th to the 24th of the month following that to which the figures apply, and the complete income

account ordinarily is not available until the 25th. The physical performance statistics, however, are based in greater part on the conductors' train reports. Those which do not come from the train reports are taken from other records of the operating department which are available a few days after the close of the month. Consequently it is possible to complete the reports of physical performance fifteen days after the close of the month, and the statistics are available at least ten days before those which relate to cost. It is highly important that the figures shall be in the hands of the supervising officers at the earliest possible date.

The underlying theory of the five forms is that the operating department is charged with a given number of locomotive-days and car-days, and is credited with its production in ton-miles or passenger car-miles. The production in ton-miles and passenger car-miles, in turn, is related to the operating department's expenditure in train-miles, locomotive-miles, and car-miles, and the supplementary statistics throw light on the components of the train-load and the car-load, as well as upon the effect of changes in the nature of the commodities handled, in the balance of traffic, in the proportion of fast and way-freights, and in other physical, traffic and operating features. The desiderata are that each locomotive and car should be employed to its capacity, and should produce the maximum of ton-miles with the minimum of train-, locomotive- and car-miles. The statistics show clearly the relation between the ton-mile production and the utilization of equipment, and the relation between the actual and potential train production. The physical performance statistics are compared at a later date with the cost statistics provided by Forms 6 and 7. These two forms are due to be completed on the 30th day of the month following that to which the figures apply.

Form 6, Locomotive and Train Costs. This report deals with the direct or "out-of-pocket" costs—those which are directly related to train-, locomotive- and car-performance. They require a separation of these primary expense accounts according to the Interstate Commerce Commission's "Rules governing the Separation of Operating Expenses between Freight Service and Passenger Service."

The basic data are reported separately for freight service and passenger service and separately for:

Locomotive repairs
Enginehouse expenses
Enginemen
Trainmen
Locomotive fuel
Other locomotive supplies
Train supplies and expenses

For the freight service the unit costs are expressed in:

Cost per locomotive-mile
Cost per train-mile
Cost per 1000 gross ton-miles

For the passenger service, they are shown as:

Cost per locomotive-mile
Cost per train-mile
Cost per passenger train car-mile

Form 7, Condensed Income Account and Operating Expenses by Primary Accounts. This form is a copy of the condensed income account and the primary expense accounts of the Interstate Commerce Commission, with certain re-arrangement and grouping to provide sub-totals of the primary expense accounts which adapt themselves to operating statistical requirements. A summary is provided to show the operating ratio divided between the seven general accounts of the Interstate Commerce Commission classification.

Form 8, Freight and Passenger Revenue Statistics. This report (which is due on the 10th day of the second month following that to which the figures apply) requires in monthly form most of the revenue statistics called for annually by the Interstate Commerce Commission. From the basic information the following units are derived and are used as supplementary data in the analysis of operating results:

Miles per ton, revenue freight (average haul)
Revenue per ton, revenue freight
Revenue per ton-mile, revenue freight
Revenue per freight train-mile
Revenue per loaded freight car-mile
Miles per passenger (average journey)
Passengers per train-mile
Passengers per passenger-carrying car-mile
Passenger revenue per passenger

Passenger revenue per passenger-mile
Total revenue per passenger train-mile
Passenger revenue per passenger-carrying car-mile.

SOME DISTINCTIVE FEATURES OF THE NEW PLAN

The foregoing will give a general idea of the scope of the plan. Attention will now be directed to some of its distinctive features. The principal innovations appear in the statistics of freight train operation, as that field contains the largest possibilities of statistical control and had the greatest need of harmonizing divergencies in statistical practice.

Gross Ton-Miles

At the outset it was decided that gross ton-miles are absolutely essential. They represent the product of the gross weight (tons of 2000 lbs.) of the train behind the tender, and the miles moved. Gross ton-miles are the superintendent's transportation product, against which his costs may be measured. All of the gross load is not paying freight. The paying freight is represented by the net ton-miles. Any complete statistical plan requires both sets of figures.

The compilation of gross ton-miles had been common west of the Mississippi River for many years, and to a smaller extent this was true also of certain important roads in the south. Such statistics, however, were not common in the east, although the tendency was toward recognizing their value.

Rating Ton-Miles

The compilation of rating ton-miles was confined to a very few railroads. Rating ton-miles are the potential ton-miles which would have been produced had all trains been loaded to 100 per cent of the slow freight rating for normal summer weather, taking account of changes in the locomotive ratings over sections of the train run. It is customary to determine, and to publish as the tonnage rating of each class of each locomotive, what each class of locomotive is capable of hauling over each run or each section of a run when there are differences in the gradients to be overcome. It was decided that this information is vital to a scientific analysis of train loading efficiency, as the ratio of the actual gross ton-miles to the potential gross ton-miles gives the

percentage of train loading efficiency. The general manager of a railroad may fairly hold his superintendents responsible for a satisfactory ratio of actual to potential, the performance in every case to be interpreted in the light of other related statistics, such as the train speed and the ratio of net ton-miles to gross ton-miles. In the very nature of things the superintendent can seldom make a perfect performance of 100 per cent. His traffic will not be evenly balanced by directions, he must run some fast-freights and way-freights with less than the full tonnage required by the slow freight tonnage rating, and the weather conditions are not always ideal.

Net Ton-Miles from the Train Reports

The net ton-miles are the product of the tons of freight in the train and the miles they are moved. The net ton-miles represent the paying part of the gross load. From the viewpoint of management the net load is more important than the gross load, as the revenues follow the net tons although the expenses follow the gross tons. It is important, then, to know the ratio of net ton-miles to gross ton-miles. That ratio is influenced by the car-load, which, in turn, is influenced by the fluctuations in the relative proportions of low-grade freight and high-grade freight. The former moves in bulk in full car-loads; the latter moves in relatively light car-loads. The ratio of net ton-miles to gross ton-miles is influenced also by the fluctuations in the empty car movement.

The net ton-miles reported on Forms 1 and 5 are computed from the conductors' train reports which among other things show the car numbers and initials, the weight of contents, the gross weight, and the points between which moved. Except in a very few isolated cases (where the value of the statistics had been recognized) net ton-miles were not available until the latter part of the second month, that is to say, the net ton-miles for January would not be complete until March 15th to March 25th. The information was taken from the waybills, the source of freight revenue statistics, and the delay in the settlement of interline waybills prevented an earlier closing of the revenue accounts. As a consequence the net ton-miles were received so late that they did not provide a satisfactory basis for the computation of train loading and car loading statistics.

Another objection applied to waybill ton-miles as a measure of train- and car-performance. Ton-miles computed from the waybills rarely corresponded with the tons actually moved during the period for which the train-miles were reported, because of the delay in taking the interline waybills into account. There was always a "lap-over" of interline waybill ton-miles omitted from the preceding period, and a shortage of interline waybill ton-miles produced in the current period but not taken into account until the next period. In theory the "lap-over" should have balanced the shortage, but in actual practice the discrepancy was often so great as to invalidate waybill tonnage as a measure of train performance for any particular month.

It was decided, therefore, to require that the net ton-miles, like the gross ton-miles, the train-miles, the locomotive-miles, the car-miles and the train-hours, should be computed from the train reports. All of the basic data, then, would come from the same source. This insures the comparability of all these related data, and definitely allocates the transportation product to the particular period under review. Steps were taken later to utilize the train report ton-miles for revenue accounting and statistical purposes, and to discontinue the computation of waybill ton-miles except in certain states which require a separation of ton-miles between interstate and intrastate.

It may occur to the minds of those who are interested in ton-mile statistics purely from the viewpoint of revenue and public service that the substitution of the statistics from the train reports may be less accurate than those from the waybills, and that the use of train report ton-miles as a divisor into freight revenue may affect the integrity of the important unit "Revenue per ton-mile." There is, however, no cause for apprehension on that score, as experience has shown that differences in the two sets of statistics are so small as to be negligible. A comparison of the net ton-miles from the waybills (before that basis was discontinued) with those taken from the train reports, shows that for all railroads for five months the variation was but 0.8 per cent. In this test the effect of the "lap-over" items is nullified because they are spread over a period of five months. The variation would be greater in the comparison of a single month.

THE TIME ELEMENT IN OPERATING STATISTICS

The importance of the time element in operating statistics had not generally been recognized. The majority of railroad men and financiers, are accustomed to think in terms of train load- ton-miles per train-mile. Relatively few have been accustomed to think in terms of ton-miles per train-hour. The latter, however, is the better index to efficiency. The train-load, by itself, takes no account of speed. Ton-miles per train-hour are the resultant of load and speed. It is analogous to the horsepower unit. It combines in itself the net effect of the operating policy between the two extremes of loading the locomotive to every ton it can drag at low speed over the ruling grade, and of sacrificing tonnage in order to make the trip quickly. There is always a critical point between the two extremes which under normal conditions will produce the maximum of ton-miles per train-hour at the minimum cost per ton-mile.

To illustrate: assume that on a given run there are sections of 1 per cent grade over which a given type of locomotive can haul 1,500 gross tons (tons of car and lading combined) at a speed of six miles per hour on these maximum grades. The speed on other sections, of course, will be greater, but we will assume that, with a normal allowance for road delays, the run of 100 miles may be made in 10 hours. At that speed the production would be 15,000 gross ton-miles per train-hour (train-load of 1,500 gross tons times train-speed of 10 miles per hour). As the train- and engine-crews are on an eight-hour day basis, they would be paid overtime for two hours. (It is unnecessary here to go into the technicalities of the wage schedules which provide that mileage rates apply unless the miles per hour in freight service are less than 12.5, in which case hourly rates, based on 12.5 miles per hour, apply.) In this case it may be found that a reduction in the tonnage rating to 1,350 tons would permit an increase in the speed and reduce the trip hours to 8, or an average speed of 12.5 miles per hour. This combination of train-load and train-speed will produce 16,875 gross ton-miles per train-hour. The ton-mile production *per train-hour* is thereby increased from 15,000 to 16,875, and the cost per ton-mile is decreased because of the elimination of overtime. In this assumed case it is plain that the 1,500 ton rating is

uneconomical. In the great majority of cases it may not be clear whether there would be any real economy in decreasing the load to increase the speed. These principles are ordinarily considered when the tonnage ratings are established, and it is the intention that they shall be set at a maximum which will not prevent the trains from moving at economical speed.

In order to provide for the time element in operating statistics, the compilation of freight train-hours was required. Form 1 show these basic data as well as gross ton-miles and net ton-miles per train-hour. It is possible, therefore, to trace the relationship between increases or decreases in the train-load and increases or decreases in the train-speed, and to note the combined effect in ton-miles per train-hour. The fluctuations in ton-miles per train-hour may, in turn, be compared with fluctuations in the cost per gross ton-mile, reported on Form 6.

The time element has recognition also in Form 5, which shows as the final and inclusive unit of freight car efficiency, "Net ton-miles per car-day." This unit is the resultant of three factors:

1. Average ton-miles per loaded car-mile
2. Per cent of loaded car-miles to total car-miles
3. Average car-miles per car-day.

If, for example, the car-load is 30 net tons, the per cent of loaded to total car-miles is 70 per cent, and the car-miles per car-day are 30, the net ton-miles per car-day are 630 (car-load—30 tons—multiplied by per cent of loaded cars—.70—multiplied by car-miles per car-day—30). An improvement in any one factor favorably influences the inclusive unit; a loss in any one factor adversely affects it. If a campaign of intensive car loading brings about an increase of 10 per cent in the car-load, to 33 net tons, but also causes a slowing up in car movement of 10 per cent, to 27 miles per day, the road is no better off. In fact there is a slight loss, as the ton-miles per car-day will be 624 instead of 630. If, further, the heavier car loading increases the empty car movement, and thereby decreases the per cent of loaded car-miles to total car-miles, say to 67 per cent instead of 70 per cent, the inclusive unit —ton-miles per car-day—will suffer a further loss—597 instead of 630. The interrelation of these factors is often overlooked. From the single viewpoint of car performance there is no advan-

tage in improving one factor if it is done at the expense of either or both of the other two factors.

It should be noted, however, that one factor in this composite unit is practically constant from the viewpoint of the roads as a whole. The total number of freight cars varies but slightly from month to month. It is affected only by additions through the purchase of new cars, by the retirement of old cars, and by the fluctuations in the daily number of cars belonging to private car lines and Canadian roads. These changes are relatively slight in their effect on the total, so that it may be said that the net ton-miles per car-day for the roads as a whole will fluctuate almost directly with increases or decreases in the volume of freight traffic. This is not so true of individual roads which have some control over the cars on their lines. In periods of thin traffic, each road endeavors to reduce its number of cars belonging to other roads. This has a tendency to shift the balance of surplus cars as between railroads and regions, but, of course, has no effect on the grand total.

In one other notable particular, the new plan recognizes the prime importance of the time element, that is in locomotive utilization. Heretofore, there were no complete data to show the distribution of the hours in the locomotive day. Form 4 contains the most radical elaboration of orthodox statistical practice, as it provides for the division of serviceable locomotive time between that spent in productive road service, that spent at terminals "standing by" both before and after the road run, and that spent in the enginehouse between trips. The latter item is sub-divided further to show how much of the time the locomotive is undergoing repairs or receiving other attention at the hands of the mechanical department forces, and how much of the time it remains idle in the enginehouse awaiting call from the transportation department.

An examination of the details of the hours of serviceable locomotives is facilitated by the requirement that the hours under each subdivision on the report shall be expressed also in percentages of total serviceable locomotive hours. Thus it is easy to compare the percentage of time on the road, at terminals and in enginehouses. When traffic is heavy it is desirable, of course, to show a high percentage of time in productive road service, and to

take steps to control the unproductive hours at terminals and in enginehouses. When traffic is subnormal, it is inevitable that the time in the enginehouse (or as stored locomotives) will increase, but there is the same necessity for watching terminal time, as the crews are paid for the hours "standing by" at the same rate as on the road. The percentages, of course, show wide variations as between roads, reflecting differences in traffic conditions, in physical facilities, and in the policy of locomotive assignment—whether to single crews, double crews, multiple crews or to pooled crews. It is not safe to draw general conclusions from the figures alone without first hand information as to local conditions.

No attempt has been made by the Railroad Administration thus far to use the statistics for road-by-road comparisons. The figures, as reported, are summarized and published, but as comparisons with the preceding year will not be possible until the October, 1919, reports are received, the full value of the report for comparative purposes will not be apparent until the full year has elapsed. But even without the last year comparison the figures for the first year have been of value, as they give a clear picture which localizes the extent of the non-use of power. There is force to the assertion that under existing conditions, with a surplus of locomotives, the value of the data is not as great as when there is a shortage of power. The continuation of the record, however, provides a bench-mark for comparisons of future performance, and will have an educative value as all concerned learn to appreciate the full significance of the figures. The low percentage of time on the road will surprise many who have little conception of what it really is. The high percentage of time at terminals (in certain instances) will throw light on overtime payments. The data should be of importance to supervisory or executive officers in passing upon recommendations for the purchase or transfer of power, or as to the necessity for improvements at terminals and enginehouses.

The requirements of Form 4 brought some protests from roads which had no statistics of distribution of locomotive-hours, and which consequently were put to some additional expense in compiling the figures. The answer of the Railroad Administration was that while it recognized the difficulties which lie in increasing the percentage of hours on the road in productive service, yet it

maintained that effective remedial measures may not be applied without a complete knowledge of the facts, not from casual observation or off-hand statements, but from a current and comprehensive record.

It is pertinent at this point to refer to one feature which is subject to misunderstanding, and concerning which the United States Railroad Administration has been criticized. Prior to federal control, the Railroads' War Board inaugurated a monthly *Summary of Freight Operation* which among other statistics, showed what was termed, "Per cent of freight locomotives in shop or awaiting shop." No clear definition was given, but it was generally understood by the reporting carriers to apply only to the locomotives held out of service for general or classified repairs, which are made in the general shops, and was not meant to embrace locomotives held out of service for running repairs or other light repairs which in most cases are made in the engine-houses, although often made in the general shops.

Under federal operation the monthly summary above referred to was continued without change in basis until October, 1918, when the standardized statistics became fully effective. Under the new plan, the policy is to hold the operating department to a high standard in locomotive utilization, and the dividing line between serviceable and unserviceable locomotives was set at those which are held 24 hours or more for repairs of any kind, whether running repairs or classified repairs. The record is kept on an hourly basis, and the average number of unserviceable locomotives per month is obtained by dividing the monthly aggregate hours of locomotives held 24 hours or more for repairs, by the total hours in the month. This change in method naturally brought about an apparently large increase in the percentage of unserviceable locomotives. The percentage (in freight service) on the last report on the old basis (September, 1918) was 14.8 per cent. On the first report on the new basis (October, 1918) it is shown as 25.1 per cent. Actually there was practically no difference in the condition of the locomotives in the two consecutive months. The difference is due entirely to the change in basis which was made under war conditions with a view to showing conditions in their worst light so that all concerned might be impressed with their responsibility for keeping locomotives employed to their

maximum productive capacity. The use of the word "unserviceable" is somewhat strained, as it is not fairly accurate (although technically correct) to say that a locomotive which is held 24 hours for an hour's repairs, is "unserviceable." Yet the line had to be drawn definitely, and it was set at 24 hours delay for repairs of any kind.

As already stated the Administration has been criticized because its reports for July, 1919, show 27.2 per cent of freight locomotives unserviceable, while the July, 1918, report on the Railroads' War Board basis shows the percentage as 14.1 per cent. Practically all of the difference is due to the change in basis. The current summaries now bear the footnote:

> The factor of "unserviceable locomotives" here used is a factor designed to be correlated with performance in transportation and is not designed to reflect and does not reflect the physical condition of the equipment. The factor reflects not merely the need for repairs but also the extent of delay in obtaining the repairs; and does this not merely with respect to classified repairs, the need for which implies actual disability in the equipment, but also with respect to running repairs for which locomotives are held 24 hours or more. To ascertain the physical condition of the equipment reference should be made to the locomotives in shop or awaiting shop for classified repairs.

Separation of Freight Train Statistics by Directions

On Form 1 all of the basic information and all of the averages or ratios are shown separately by directions—east, west and total. Where the movement of traffic as a whole is not east and west, it may be shown as north and south, or branches which run north or south may be combined with east or west according to traffic movement. The requirement of separation by direction is designed to throw light on the effect of unbalanced traffic, and to permit a separate analysis of the performance in each direction. Such an analysis is essential to an accurate determination of the effect of fluctuations by directions.

Freight traffic usually is unbalanced. There is usually what is called the "direction of prevailing traffic," although with seasonal or other traffic fluctuations it may alternate between east and west. Ordinarily it is unnecessary to pay much attention to train loading in the light direction, as the locomotives and crews in the direction of heavy traffic must be returned in the light direction with little regard to train loading. It may be, however, that the

grades are easy in the direction of traffic and are heavy in the opposite direction. In that case it is probable that the train loading in the direction of light traffic requires the greatest supervision. In one specific case the westward gross tons normally are from 55 per cent to 65 per cent of the eastward gross tons, but the heaviest grades are against the westward movement. For a given type of locomotive the eastward rating is 2,000 gross tons; westward it is 1,200 tons, or 60 per cent of the eastward rating. It is plain, then, that in this case the eastward direction is controlling so long as the westward gross tons are not more than 60 per cent of the eastward gross tons. When it exceeds 60 per cent, it is the westward movement which controls the number of locomotives and crews.

This instance will illustrate the importance of the required separation in the statistics of traffic, of train-, locomotive-, and car-mileage, and of train-hours. Heretofore, its importance has been recognized in the statistical practice of but very few railroads.

ACTUAL FIGURES FROM ONE REPORT.

Space will not permit the reproduction of all of the forms and summaries. A single example will suffice to show the design of one form, and to illustrate the completeness of the data pertaining to freight train operation. The report herein reproduced contains the actual figures of one railroad on Form 1 for the month of May, 1919, compared with May, 1918. In this case the road had unusually complete statistics for 1918, and was able to adapt its records to fit the comparative requirements of the new report.

In analyzing this report we note first that the gross ton-miles show a decrease of 20.4 per cent. This change in the actual gross production should be compared with the potential. The rating ton-miles show a decrease of 21.5 per cent. This comparison indicates an improvement in loading to the locomotive rating. A glance at Item 14 shows an increase of 1.4 per cent in the per cent of actual to potential. We note further, however, that the improvement occurred wholly in westward movement. The eastward performance shows a decrease in loading efficiency. The details by directions, under Items 5 and 6, show that the traffic is unbalanced, the prevailing direction being eastward. The

To be mailed, on or before 15th of following month, to Operating Statistics Section, Division of Operation, U. S. Railroad Administration, Washington, D.C.

UNITED STATES RAILROAD ADMINISTRATION
DIRECTOR GENERAL OF RAILROADS

Form OS-1
Page 1 of 2 pages
(Revised Feb. 1-19)

A. B. & C. RAILROAD
(Name of reporting carrier)

FREIGHT TRAIN PERFORMANCE

(Not including mixed, special, or motor car trains)

Month of MAY, 1919, compared with same month of previous year.

Increase, black. Decrease, red.

ITEM	MONTH OF MAY		INCREASE OR DECREASE	
	THIS YEAR	LAST YEAR	AMOUNT	PER CENT
1. (*a*) Average miles of road operated.....(*Note A*)	3,563.2	3,561.2	2.0	.1
(*b*) Average miles other main tracks operated (*Note A*)	25.3	25.3		
2. Train miles (*Note B*):				
(*a*) East	181,796	261,469	d 79,673	d 30.5
(*b*) West	177,465	244,537	d 67,072	d 27.4
(*c*) Total	359,261	506,006	d 146,745	d 29.0
3. Locomotive miles (*Note B*):				
(*a*) Principal and helper, east	190,174	280,199	d 90,025	d 32.1
(*b*) Principal and helper, west	184,121	259,802	d 75,681	d 29.1
(*c*) Total principal and helper, east and west	374,295	540,001	d 165,706	d 30.7
(*d*) Light, east	2,195	3,057	d 862	d 28.2
(*e*) Light, west	6,431	16,349	d 9,918	d 60.7
(*f*) Total light, east and west	8,626	19,406	d 10,780	d 55.5
(*g*) Grand total, east and west	382,921	559,407	d 176,486	d 31.5
4. Car miles (*thousands*) (*Note B*):				
(*a*) Loaded, east	6,030	7,836	d 1,806	d 23.0
(*b*) Loaded, west	3,058	2,845	213	7.5
(*c*) Loaded, total	9,088	10,681	d 1,593	d 14.9
(*d*) Empty, east	704	856	d 152	d 17.8
(*e*) Empty, west	3,237	4,144	d 907	d 21.9
(*f*) Empty, total	3,941	5,000	d 1,059	d 21.2
(*g*) Caboose, east	186	281	d 95	d 33.8
(*h*) Caboose, west	183	263	d 80	d 30.4
(*i*) Caboose, total	369	544	d 175	d 32.2
(*j*) Total, east	6,920	8,973	d 2,053	d 22.9
(*k*) Total, west	6,478	7,252	d 774	d 10.7
(*l*) Grand total	13,398	16,225	d 2,827	d 17.4
5. Gross ton miles (*thousands*) (*Note C*):				
(*a*) East	267,713	362,186	d 94,473	d 26.1
(*b*) West	182,302	202,915	d 20,613	d 10.2
(*c*) Total	450,015	565,101	d 115,086	d 20.4
6. Rating ton miles (*thousands*) (*Note D*):				
(*a*) East	299,506	399,123	d 99,617	d 25.0
(*b*) West	268,963	324,897	d 55,934	d 17.2
(*c*) Total	568,469	724,020	d 155,551	d 21.5
7. Net ton miles (*thousands*) (*Note E*):				
(*a*) East	128,001	184,919	d 56,918	d 30.8
(*b*) West	55,322	60,429	d 5,107	d 8.5
(*c*) Total	183,323	245,348	d 62,025	d 25.3
8. Train hours (*Note F*):				
(*a*) East	16,029	22,970	d 6,941	d 30.2
(*b*) West	16,126	20,385	d 4,259	d 20.9
(*c*) Total	32,155	43,355	d 11,200	d 25.8

NOTES

(A) Miles of road—miles of first running track. Miles other main tracks—miles of second, third, fourth, or other multiple running tracks, not including yard tracks and sidings.

(B) Follow "Classification of train miles, locomotive miles, and car miles," Interstate Commerce Commission, July 1, 1914. Include electric locomotive trains, but exclude mixed, special, and motor car trains. Train miles—Account 801, both ordinary and light; locomotive miles—Account 811; car miles—Account 821. Where movement of traffic as a whole is not east and west, substitute north for east and south for west, or combine north and south with east and west according to traffic movement.

(C) Gross ton miles—tons of 2,000 lbs. behind locomotive tender (cars, contents, and caboose) moved one mile; to be computed from conductors' train reports. Include electric locomotive trains, but exclude mixed, special, and motor car trains.

(D) Rating ton miles—the potential gross ton miles which would have been produced had all trains been loaded to 100 per cent of the slow freight rating for normal weather conditions, taking account of changes in rating over sections of the run. When the potential train load in the direction of favoring grades is now expressed in number of cars an arbitrary tonnage rating should be used as the basis for Item 6.

A. B. & C. RAILROAD
(Name of reporting carrier)

FREIGHT TRAIN PERFORMANCE

(Not including mixed, special, or motor car trains)

Month of MAY, 1919, compared with same month of previous year. Increase, black. Decrease, red.

ITEM	MONTH OF MAY		INCREASE OR DECREASE	
	THIS YEAR	LAST YEAR	AMOUNT	PER CENT
AVERAGES				
9. Per freight train mile:				
(a) Locomotive miles, east (*excl. light*)..(3a÷2a)	1.046	1.072	d .026	d 2.4
(b) Locomotive miles, west (*excl. light*)...(3b÷2b)	1.038	1.062	d .024	d 2.3
(c) Locomotive miles, total (*excl. light*)...(3c÷2c)	1.042	1.067	d .025	d 2.3
(d) Loaded car miles, east.....(4a÷2a)	33.2	30.0	3.2	10.7
(e) Loaded car miles, west.....(4b÷2b)	17.2	11.6	5.6	48.3
(f) Loaded car miles, total.....(4c÷2c)	25.3	21.1	4.2	19.9
(g) Empty and caboose car miles, east (4d+4g)÷2a	4.9	4.3	.6	14.0
(h) Empty and caboose car miles, west (4e+4h)÷2b	19.3	18.0	1.3	7.2
(i) Empty and caboose car miles, total (4f+4i)÷2c	12.0	11.0	1.0	9.1
(j) Total car miles, east.....(4j÷2a)	38.1	34.3	3.8	11.1
(k) Total car miles, west.....(4k÷2b)	36.5	29.7	6.8	22.9
(l) Total car miles, total.....(4l÷2c)	37.3	32.1	5.2	16.2
(m) Gross ton miles, east.....(5a÷2a)	1,472.6	1,385.2	87.4	6.3
(n) Gross ton miles, west.....(5b÷2b)	1,027.3	829.8	197.5	23.8
(o) Gross ton miles, total.....(5c÷2c)	1,252.6	1,116.8	135.8	12.2
(p) Rating ton miles, east.....(6a÷2a)	1,647.5	1,526.5	121.0	7.9
(q) Rating ton miles, west.....(6b÷2b)	1,515.6	1,328.6	187.0	14.1
(r) Rating ton miles, total.....(6c÷2c)	1,582.3	1,430.9	151.4	10.6
(s) Net ton miles, east.....(7a÷2a)	704.1	707.2	d 3.1	d .4
(t) Net ton miles, west.....(7b÷2b)	311.7	247.1	64.6	26.1
(u) Net ton miles, total.....(7c÷2c)	510.3	484.9	25.4	5.2
10. Per freight train hour:				
(a) Train miles, east (*speed in miles per hour*)(2a÷8a)	11.3	11.4	d .1	d .9
(b) Train miles, west (*speed in miles per hour*).....(2b÷8b)	11.0	12.0	d 1.0	d 8.3
(c) Train miles, total (*speed in miles per hour*).....(2c÷8c)	11.2	11.7	d .5	d 4.3
(d) Gross ton miles, east.....(5a÷8a)	16,701.8	15,767.8	934.0	5.9
(e) Gross ton miles, west.....(5b÷8b)	11,304.8	9,954.1	1,350.7	13.6
(f) Gross ton miles, total.....(5c÷8c)	13,995.2	13,034.3	960.9	7.4
(g) Net ton miles, east.....(7a÷8a)	7,985.6	8,050.5	d 64.9	d .8
(h) Net ton miles, west.....(7b÷8b)	3,430.6	2,964.4	466.2	15.7
(i) Net ton miles, total.....(7c÷8c)	5,701.2	5,659.0	42.2	.7
11. Net ton miles per loaded car mile:				
(a) East.....(7a÷4a)	21.2	23.6	d 2.4	d 10.2
(b) West.....(7b÷4b)	18.1	21.2	d 3.1	d 14.6
(c) Total.....(7c÷4c)	20.2	23.0	d 2.8	d 12.2
12. Per cent loaded to total car miles (*excl. caboose*):				
(a) East.....4a÷(4a+4d)	89.5	90.2	d .7	d .8
(b) West.....4b÷(4b+4e)	48.6	40.7	7.9	19.4
(c) Total.....4c÷(4c+4f)	69.8	68.1	1.7	2.5
13. Per cent net ton miles to gross ton miles:				
(a) East.....(7a÷5a)	47.8	51.1	d 3.3	d 6.5
(b) West.....(7b÷5b)	30.3	29.8	.5	1.7
(c) Total.....(7c÷5c)	40.7	43.4	d 2.7	d 6.2
14. Per cent gross ton miles to rating ton miles:				
(a) East.....(5a÷6a)	89.4	90.7	d 1.3	d 1.4
(b) West.....(5b÷6b)	67.8	62.5	5.3	8.5
(c) Total.....(5c÷6c)	79.2	78.1	1.1	1.4

(E) Net ton miles—tons of revenue and nonrevenue freight moved one mile; to be computed from the conductors' train reports.

(F) Train hours—the elapsed time of trains between the time of leaving initial terminals and time of arrival at final terminals, including delays on the road. May be taken from conductors' train reports or from dispatchers' train sheets.

percentages of decrease show that the loss in traffic both in gross and net (particularly in net) was relatively greater eastward than westward.

The next step is to compare the gross ton-miles with the train-miles. The percentages of change are 20.4 per cent decrease in gross ton-miles and 29.0 per cent decrease in train-miles. These figures indicate an improvement in the train-load. The results are shown in Item 9. The eastward gross train-load shows an increase of 6.3 per cent, the westward load an increase of 23.8 per cent, and in both directions combined, the increase is 12.2 per cent.

Attention should now be directed to the relation between locomotive-miles and train-miles. The train-miles show a decrease of 29.0 per cent. The decrease in principal and helper locomotive-miles is 30.7 per cent. We note in passing that there has been a substantial saving in light locomotive-miles—locomotives run without trains. The relation between the train-miles and locomotive-miles is seen in Item 9, which shows a decrease of 2.3 per cent in the locomotive-miles per train-mile. It is evident, therefore, that the increase in the train-load was not due to the greater use of multiple locomotives.

It might be of interest in this case to ascertain why the locomotive-miles decreased relatively more than the rating ton-miles. A simple computation (Item 6-c divided by Item 3-c) shows that the average rating per locomotive in 1919 was 1,519 as against 1,341 in 1918. This difference indicates one or more of six things: (1) the acquisition of new locomotives of greater power; (2) the relatively greater use of heavier power and relatively smaller use of lighter power, the latter being stored; (3) the application of superheaters to locomotives not heretofore so equipped; (4) an upward revision of tonnage ratings; (5) relatively more traffic on the divisions which have the heavier tonnage ratings; or (6) grade rivisions which permit of heavier train loading. In this particular case the increase in the average rating is due to a combination of four out of the six reasons just suggested.

One reason for the better westward performance is seen in the car-miles. They show a heavy decrease in loads eastward, but westward we find an increase of 7.5 per cent. It is of interest here to glance at the average car-load, Item 11. It shows a loss

of 12.2 per cent, with but little difference in the change as between directions. The difference between directions is greater, however, in the per cent of loaded to total car-miles. Eastward the proportion of loads decreased slightly while in the westward direction there is an increase of 19.4 per cent. Both the car-load and the percentage of loaded cars have a material effect on the car-load, as it is possible to handle a greater gross train-tonnage in heavily loaded cars with few empty cars, than in lightly loaded cars with a large proportion of empties. The unit resistance (per ton) of an empty car is approximately twice as great as that of a car loaded to its weight capacity. A locomotive on a given run may be able to haul 3,000 gross tons in fully loaded coal cars, yet be unable to haul more than 2,400 gross tons of empty or very lightly loaded cars.

Attention may next be directed to the net ton-miles so as to see the relation between the paying load and the gross load of the train. It is noted that the net ton-miles show a decrease of 25.3 per cent, the loss being much greater eastward. As the loss in gross ton-miles is 20.4 per cent, it is plain that the net ton-miles this year bear a lower percentage to gross. The details are shown in Item 13. The loss was altogether in eastward movement. Its per cent of net to gross is 6.5 per cent less than last year, while the westward movement shows an increase of 1.7 per cent, the combined unit showing a loss of 6.2 per cent.

Now, we may examine the effect of the time element. Train-hours show a decrease of 25.8 per cent, while train-miles show a decrease of 29.0 per cent. This indicates a loss in train-speed. Item 10 shows the extent of the loss—4.3 per cent decrease in miles per hour. The decrease is greater in the westward direction.

The combined effect of changes in gross train-load and speed is shown in the gross ton-miles per train-hour. In this case there is a gain in one factor and a loss in the other factor. The gross train-load shows an increase of 12.2 per cent; the train speed shows a decrease of 4.3 per cent. The gain in the load was sufficient to offset the loss in the speed, consequently we find an increase of 7.4 per cent in gross ton-miles per train-hour.

Finally, we may turn to the unit which is the net result of those already discussed—the net ton-miles per train-hour. The figures

show a slight improvement—an increase of 0.7 per cent. The eastward performance shows a loss of 0.8 per cent, but the westward performance reflects a gain of 15.7 per cent. The relatively small gain in net ton-miles per train-hour, compared with gross ton-miles per train-hour, is due to the lower ratio of total net ton-miles to total gross ton-miles. And, as already stated, this is due to a smaller car-load, although the loss in that factor is lessened by a relatively smaller gain in the per cent of loaded to total car-miles.

The foregoing comments are intended merely to be suggestive. No two persons will follow the same order in undertaking an analysis of the figures. It is plain, however, that whether we proceed from the basic data to the final inclusive unit, or work backward from that unit, it is easy to trace the effect of the changes in each factor, and to proceed with intelligent inquiries designed to bring out the reasons for the relatively poorer performance in the one direction. The statistics on this form should, of course, be compared with those on the reports of locomotive performance, of distribution of locomotive hours, of freight car performance, and of locomotive and train costs, as they are all interrelated.

PUBLICATION OF SUMMARIES

Reference has already been made to the fact that the policy of the United States Railroad Administration is to disseminate the statistical summaries so that the Federal Managers and other operating officials of the individual roads may have complete and current information, not only with respect to their own performance, but also with respect to the comparative statistics of all other railroads. This is accomplished by monthly summaries which show for each road and for each region the more important items compiled from the individual reports on Forms 1 to 8, inclusive. These summaries are:

Freight Train and Freight Locomotive Performance (based on Forms 1 and 3).

Passenger Train and Passenger Locomotive Performance (based on Forms 2 and 3).

Number of Locomotives and Distribution of Locomotive Hours (based on Form 4).

Freight Traffic Movement and Car Performance (based on Form 5).

Freight Locomotive and Freight Train Costs (based on Form 6).

Condensed Income Account (based on Form 7).
Passengers Carried One Mile (based on Form 8).

The data, with two exceptions, are shown both for the current and the previous year, with the percentages of increase or decrease in the significant items. The two exceptions are the summaries of Forms 1 and 4. Complete comparison with the previous year will not be practicable until October, 1919, as the general compilation of gross ton-miles, rating ton-miles and train-hours on Form 1, and the distribution of locomotive-hours on Form 4, were not fully under way until October, 1918.

SUMMARY

In conclusion it may be stated briefly that the United States Railroad Administration, in the narrower field of operating statistics, has brought about in unification and standardization, practically what the Interstate Commerce Commission has done in the broader field of railroad accounting. The new plan of operating statistics supplements and fits into the accounting requirements of the Interstate Commerce Commission, and requires no duplication of accounting work. The new forms which pertain to freight performance and the utilization of locomotives and freight cars, are much in advance of the previous practice, and place special emphasis on the importance of the time element in train, locomotive and car performance. Gross ton-mile and train-hour statistics are now universally available, the freight train data are now available by directions, and the new basis for compiling net ton-miles provides statistics which are properly comparable with train-, locomotive-, car- and gross ton-miles.

The figures are now available much earlier than was previously the case, and the monthly summaries, generously distributed, enable each operating official to compare his results with those of his neighbors without the former uncertainties and qualifications as to bases and methods.

The new plan has accomplished its primary purpose of providing the Director General and his staff with the basic data and the significant averages, ratios and unit costs which relate to or furnish indices of operating efficiency. It has also done much, as a secondary but equally important purpose, in inspiring an added interest in the figures among Federal Managers and their

subordinates. It is realized that statistics are valuable only to the extent that they are studied and their indications acted upon, and that the greatest measure of value comes from local rather than from central use. There is gratifying evidence of a tendency locally to take more interest in the returns, and to go to a greater extent in making comparisons with other roads and regions. This greater interest on the part of those directly responsible for results must inevitably be translated into terms of increased efficiency.

Unfortunately, it is not possible to measure the effect in any definite terms, as the efficiency of operation during the period of the war and since the signing of the armistice has been so greatly influenced by other factors, such as decreased traffic, higher material costs, increased wages, shorter working hours, loss of experienced employes, and high labor turnover, as to overshadow the benefits inherent in the new statistical plan. It is clearly evident, however, that the higher material costs and increased wage rates make it necessary, in greater degree than ever before, that those in authority should have complete and accurate statistics as aids to intelligent management. It is plain, also, that whatever the plan of railroad management subsequent to federal control, it will be highly desirable to continue a statistical policy which will afford accurate and complete comparisons of operating efficiency.